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IX.—*On the Fall of the Jordan, and of the Principal Rivers in the United Kingdom.* By AUGUSTUS PETERMANN, F.R.G.S.

[Read Feb. 28, 1848.]

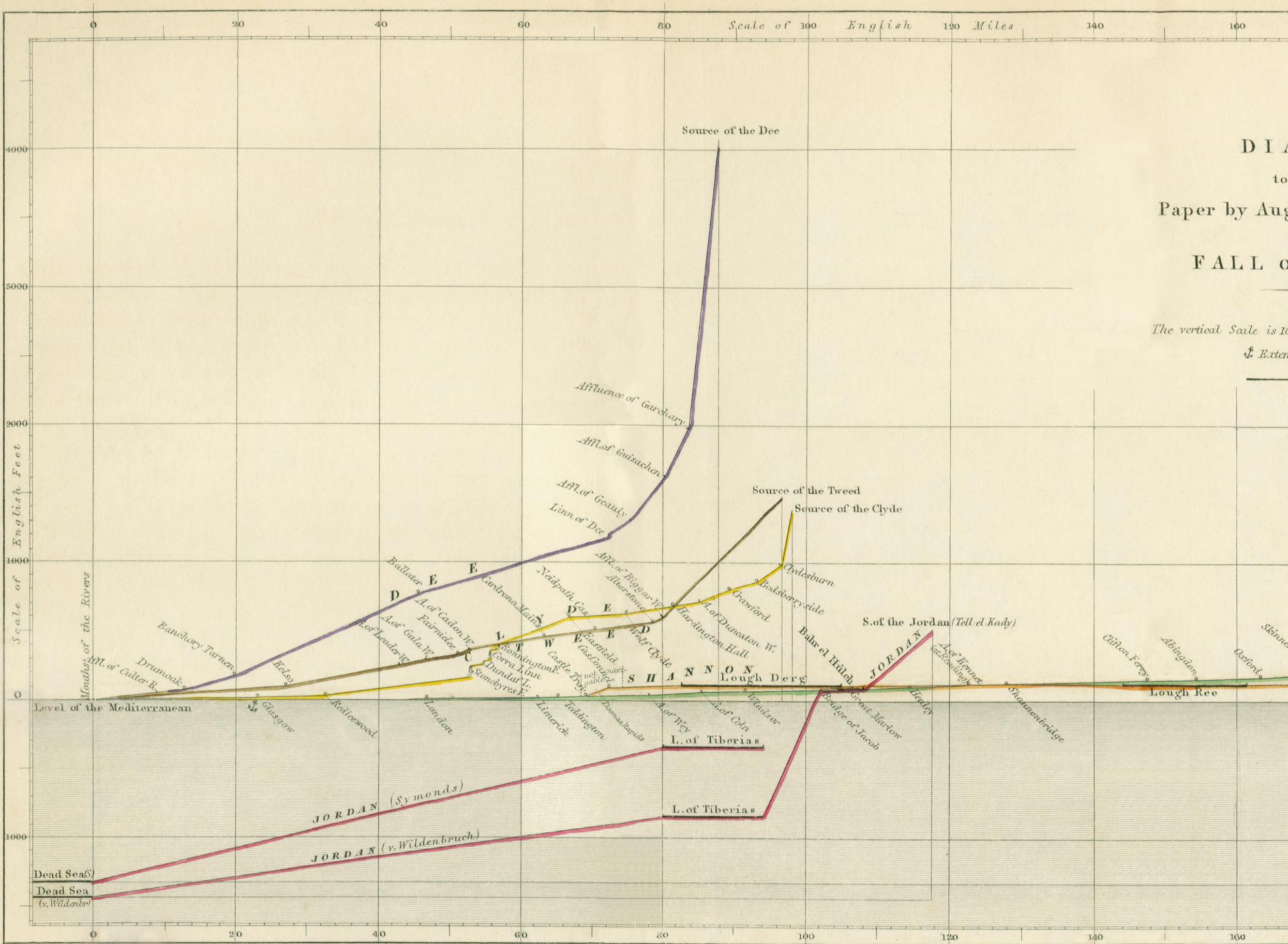
THE depression of the Dead Sea and of the Valley of the Jordan has, ever since its discovery in 1837, excited the interest of the Royal Geographical Society of London; and recently its attention has been further invited to the subject by a very important communication from Professor Robinson of New York. In it he draws especial notice to the fall of the Jordan, which he calculates from various measurements to be at the rate of 16·4 feet per geographical mile (= 14·3 per statute mile); and he appears to regard such a fall as being "very remarkable," owing to the circumstance that no cataracts or decided rapids have hitherto been discovered to account for it. He considers such a fall without cataracts as an "unusual" phenomenon, owing to his observation of the fact that several rivers which he enumerates differ very materially from the Jordan in that respect.

In this paper it is intended to lay before the Society a few remarks on the depression of the Dead Sea and on the fall of various rivers in Great Britain, and to illustrate by well-known examples, that even if it be admitted that the Jordan falls without cataracts at the rate of 14·3 feet per mile, there is nothing very remarkable in such a fall.

The depression of the Dead Sea and Jordan valley, after repeated attempts to ascertain it by barometrical measurements since 1838, was in 1841 measured by Lieut. Symonds by trigonometrical operations, the results of which, generally speaking, are much more to be relied on than barometrical observations; yet the discrepancies between the results of the trigonometrical and the repeated barometrical measurements have called forth from different quarters the desire that the trigonometrical results should be finally re-examined by that method which, so far as regards accuracy, has the preference over both barometrical and trigonometrical measurements—namely, a series of levellings to be carried from the level of the Mediterranean to the basin of the Dead Sea.

Professor Robinson suggests two reasons for the possibility that the results of Lieut. Symonds' trigonometrical measurements cannot be considered as fully solving the problem of the depression of the Dead Sea and Jordan valley—

1st. The discrepancy of the trigonometrical and barometrical results.


DIA

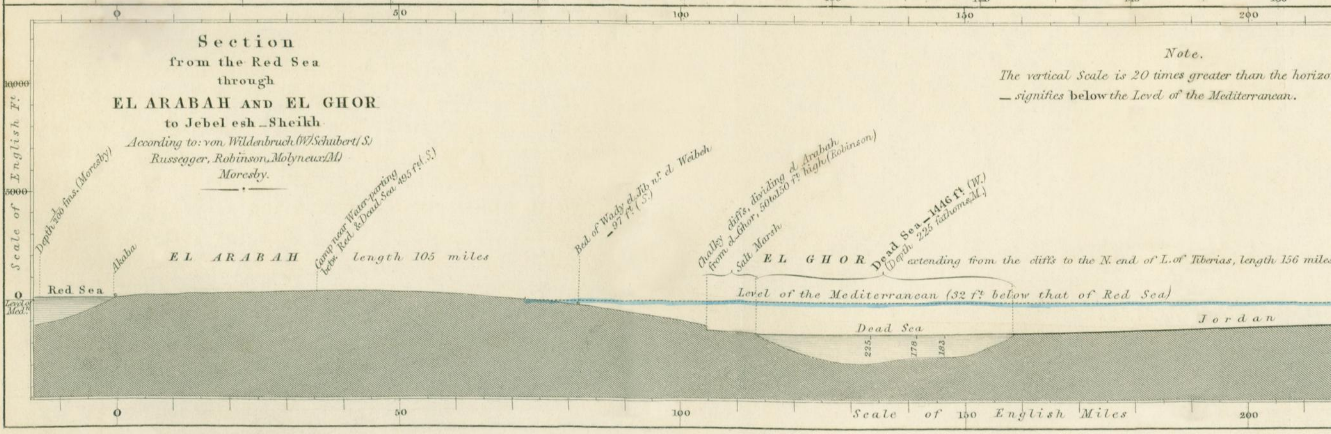
to

Paper by Aug

FALL o

The vertical Scale is 10

⚓ *Exten*


Section
from the Red Sea through EL ARABAH AND EL GHOR to Jebel esh_Sheikh

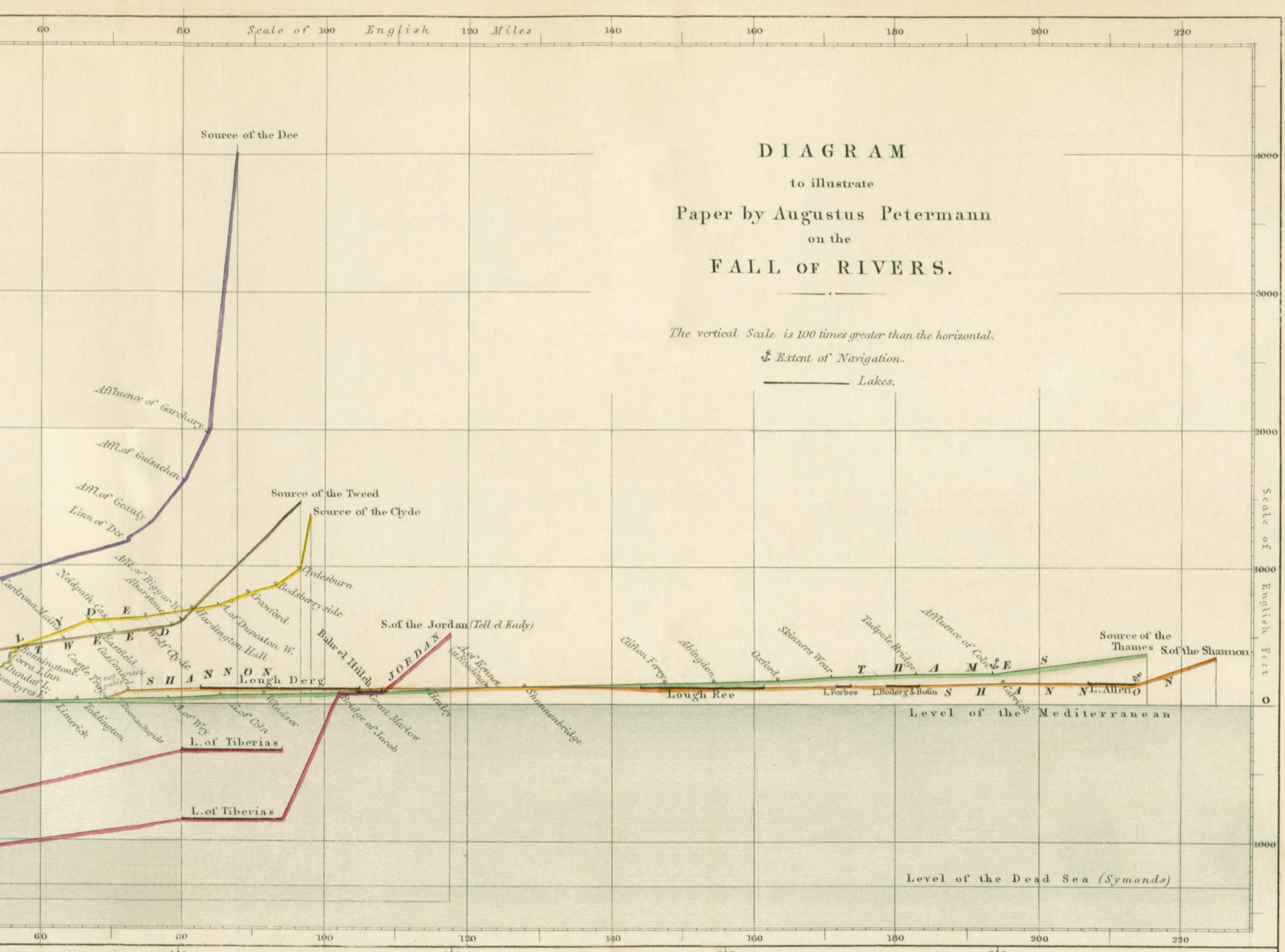
According to: von Wildenbruch (W.) Schubert (S.)
Russegger, Robinson, Molyneux (M.)
Moresby.

Note.

The vertical Scale is 20 times greater than the horizo
_ *signifies* **below** *the Level of the Mediterranean.*

0
50
100
150
200
10000
5000
0
Level of Medn.
Scale of English Ft.
Depth 200 fms. (Moresby)
Akaba
Red Sea
EL ARABAH length 105 miles
Camp near Water-parting betw. Red & Dead Sea 495 ft.(S.)
Bed of Wady el Jib nr. el Weibeh _97 ft. (S.)
Chalky cliffs, dividing el Arabah from el Ghor, 50 to 150 ft high (Robinson)
Salt Marsh
EL GHOR
Dead Sea _1446 ft. (W.) (Depth 225 fathoms M.)
extending from the cliffs to the N. end of L.of Tiberias, length 156 miles
Level of the Mediterranean (32 ft. below that of Red Sea)
Jordan
Dead Sea
225
178
183
0
50
100
Scale of 150 English Miles
200

Published for the Journal of the Royal Geographical Society, by John Murray, Albemarle St. London 1848.



DIAGRAM

to illustrate

Paper by Augustus Petermann

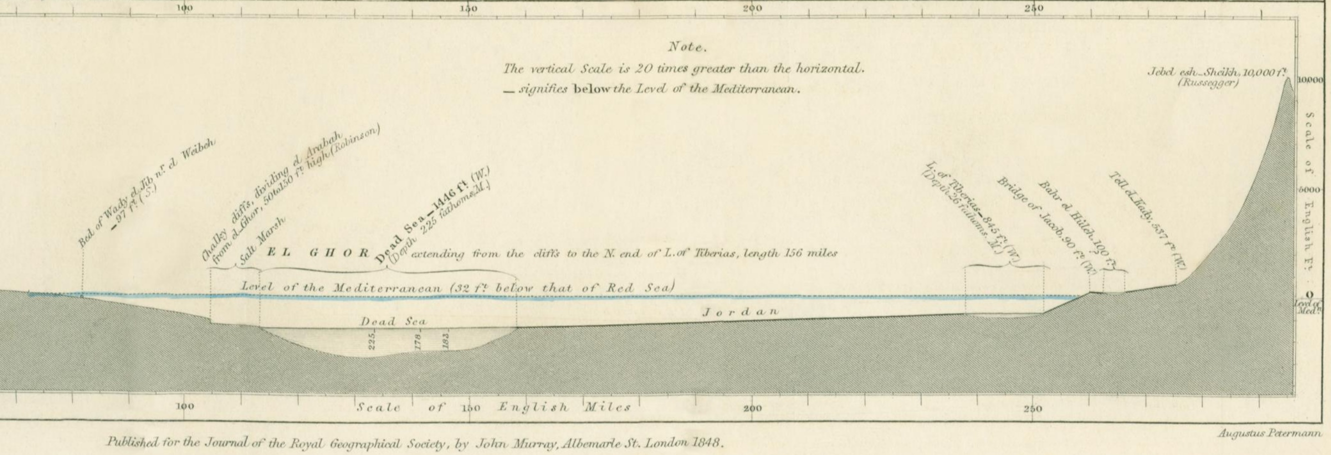
on the

FALL OF RIVERS.

The vertical Scale is 100 times greater than the horizontal.

⚓ *Extent of Navigation.*

— *Lakes.*



Note.

The vertical Scale is 20 times greater than the horizontal.

— signifies below *the Level of the Mediterranean.*

Published for the Journal of the Royal Geographical Society, by John Murray, Albemarle St. London 1848.

Augustus Petermann

2ndly. The anomaly of the descent of the Jordan, according to the trigonometrical results, when compared with the fall of other streams.

For the investigation of the first point, it will be of importance to examine all the barometrical measurements of the Dead Sea and the Lake of Tiberias, which have been made up to this time.

Professor Robinson has taken no notice whatever of the measurements of the Prussian Consul-General Herr von Wildenbruch, which were communicated to the Royal Geographical Society of Berlin in 1846, and which may claim the first place in point of accuracy amongst all barometrical measurements hitherto made, owing to the circumstance that they were checked by the simultaneous observations of a second barometer at the level of the Mediterranean.*

		Dead Sea. (Original meas.)		L. of Tiberias. (Original meas.)		Dead Sea.	L. of Tiberias.	Difference between the two Lakes.
		Fr.met	Fr. ft.	Fr.met.	Fr. ft.	Eng. ft.	Eng. ft.	Eng. ft.
March 1838 May 1839	De Bertou † (Barom.)	419·0	..	230·3	..	1374·7‡	755·6	619·1
November 1838 December 1838	Russegger (Barom.) .	..	1341·0§	..	625·0	1429·2	666·1	763·1
1845	Von Wildenbruch (Barom.)	..	1351·6	..	793·3	1446·3	845·5	600·8
					Mean =	1416·7	755·7	661·0
1841	Symonds (Trigonom.)	..	..	..	..	1312·2	328·1	984·1

However great may be the discrepancies in the preceding figures, they exhibit some analogous features which are of considerable importance. When we compare the three barometrical results apart from Lieut. Symonds, we perceive a discrepancy, taking maximum and minimum, for the depression of the Dead Sea of 71·6 feet; and for that of the Lake of Tiberias of 179·4 feet.

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* These observations were made by the Marquis de St. Simon, commander of the French ship of war Alcibiade, and both barometers were accurately compared. (They were made, as it appears, on board the vessel.) See Monatsberichte der Gesellschaft für Erdkunde zu Berlin, Jahrgang 1845 to 1846.

† The merit of the first actual measurement of the level of the Dead Sea is due to the Comte de Bertou. Schubert was the first who took a barometer to the Holy Land, but he failed in ascertaining the depression of the Dead Sea; owing to the inefficiency of his barometer, he could only make an estimate, the result of which, about 600 French feet, or 639·5 English feet, as compared with his measurement of the Lake of Tiberias, 570·2 English feet, makes a difference between the two lakes of only about 70 feet, which, as it is so very much at variance with all other measurements, cannot be taken into account.

‡ The measurement of De Bertou, as given by Robinson at 406 metres (= 1332 English feet), is only the result of a first calculation; the *ultimate* result, drawn from all his observations, both in March, 1838, and May, 1839, gives 419·0 metres (= 1374·7 English feet). See Bull. Soc. Géogr., xii., 1839, p. 166.

§ This is stated by Prof. Robinson as 1319 French feet. See Reisen, &c., 1835-1841, von J. Russegger, iii. p. 184.

These discrepancies in barometrical measurements, executed by three different parties, at different times, with different instruments, and in general under different circumstances, are not great; and in the absence of a more accurate method of measurement, one would never have hesitated to consider the mean of the three measurements as a pretty fair approximation to the truth: for the Dead Sea this mean is 1416·7 feet, and for the Lake of Tiberias = 755·7 feet; the trigonometrical results are 1312·2 and 328·1 feet.

The discrepancy for the Dead Sea will be 104·6 feet. This is not altogether unsatisfactory, and does by no means justify a doubt in the accuracy of the trigonometrical operations; there is unquestionably also much weight in Lieut. Symonds' having decidedly expressed himself as certain of the accuracy of his trigonometrical observations, the different parts of which he found agreeing with each other.*

The more unaccountable is the very great difference we observe between his results and those of the three barometrical observations for the depression of the Lake of Tiberias: it is 427·6 feet—*i. e.* more than four times greater than that for the Dead Sea. Symonds' operations for the Lake of Tiberias were quite independent of those for the Dead Sea; but his account of them is far less complete than for those of the latter, nor does he express his opinion about the result, as he did for that of the Dead Sea. And what is of still greater importance, there is a very considerable discrepancy between his first and subsequent calculations—the first giving only 84 feet, and the latter 328·1 feet, below the Mediterranean. On the other hand, the barometrical measurements of the Lake of Tiberias and those of the Dead Sea were not independent of each other, and were made successively at short intervals.

The results for the level of the Lake of Tiberias should therefore be considered in the same degree approximately correct as those for the Dead Sea. And on this ground the great variance of 427·6 feet between the results of Symonds and those of De Bertou, Russegger, and Von Wildenbruch, can scarcely be attributed to a *threefold error* on the part of the three last-named observers.

On this consideration I conclude that there seems to be as little ground to doubt the accuracy of Lieut. Symonds' result regarding the depression of the Dead Sea on the one hand, as on the other we have reason to suspect the correctness of his observations on the Lake of Tiberias.

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* Journ. of R. Geog. Soc. 1842, p. lxi.

Should my suggestion prove to be correct, and the level of the Lake of Tiberias be ascertained to accord more with the barometrical measurements, the descent of the Jordan will then be reduced one-third.

But previously to submitting a few remarks on the descent of the Jordan, I cannot forbear noticing an idea, which, however vague and hypothetical it may appear, might yet be a hint for future investigations, and which at any rate cannot be misplaced here, were it only to claim more of impartiality for the important labours of Lieut. Symonds. In examining the results of De Bertou, Russegger, and Von Wildenbruch, it is curious to observe, that the depression both of the Dead Sea and of the Lake of Tiberias increases in a chronological order, with the only exception of Russegger's 666·1 feet for the Lake of Tiberias.

Schubert's measurement of the Lake of Tiberias, a year previous to those enumerated in the foregoing table, confirms also that progress of increase; and likewise De Bertou's observations in 1838 give a greater figure than his first in 1837.

The degree of the increase within a period of seven or eight years, from Schubert and De Bertou to Von Wildenbruch, amounts to 71·7 feet for the Dead Sea, and 275·3 feet for the Lake of Tiberias.

To make this rate of increase the basis of a speculation on the gradual sinking of the basin of the Dead Sea, is at present out of the question; the observations we possess are too scanty. Although the phenomenon of the sinking and rising of land is a well-established fact, no one would ever suppose that so great a rate of sinking as from 71·7 feet to 275·3 feet could have passed unnoticed by the inhabitants and travellers in such a country where it occurs, but that there may be a continual change going on in the level of that basin, similar to that in the Scandinavian peninsula (or, if we take a more analogous instance, that of the Aralo-Caspian basin*)—no one would doubt, especially since it is well proved that the whole Jordan valley with its lakes not only have been, but still are, subject to volcanic action. " The bituminous and sulphureous sources of the Dead Sea," says Volney, " the lava, the pumice-stones thrown upon its banks, and the hot-baths of Tiberias, demonstrate that the seat of a subterraneous fire is not yet extinguished. Clouds of smoke are often discovered to rise from the lake, and new crevices to be formed on its shore." And Russegger observes that the mountains between Jerusalem and the Jordan, in the valley of the Jordan itself, and those around the Dead Sea, bear unequivocal evidence of volcanic agency, such as disruptions, upheaving, faults, &c. &c.; proofs of which agency are still notorious in the continual earthquakes, hot-springs, and formations of asphalt.

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* Humboldt's Central Asien, Bd. I. pp. 522, *seq.*

Should the result of a measurement by levellings show only a slight difference from that of Lieut. Symonds, and favour the supposition of a sinking still taking place, the question would arise, whether to attribute it to a defect in the trigonometrical operations or to a change in the levels.

I now proceed to an examination of the fall of rivers in general, in order to show that the descent of the Jordan, which from the Lake of Tiberias to the Dead Sea amounts, according to the trigonometrical results, to 984·1 feet, does not stand in contradiction with the general facts of the physical development of rivers.

The fall of rivers.—This interesting branch of physical geography presents in its comparative results such striking anomalies as perhaps have never before been anticipated. There are rivers in this country that are of the same aggregate size and descent, and the one forms in its course a series of considerable waterfalls, the heights of some of which approach nearly to 100 feet; whilst the other, equivalent, as before mentioned, in size and fall, presents not even a single waterfall or cataract, nay, not even one decided rapid.

To ascertain the rate of fall, there are two points, the accurate knowledge of which is necessary—1st, the length of the river in question; 2nd, its elevation.

The length of the river, that is to say, the development of its course, is greatly influenced by the extent of its windings. These windings in their true extent can only be delineated with sufficient accuracy in maps of a very large scale, such as is adapted for national maps, as the windings which rivers generally exhibit disappear in reduced maps to such a degree that a great difference is produced in the calculations.

For the purpose of forming a judgment of the rate of the decrease of a river's course by constructing different maps in decreasing scales, I made the following inquiry regarding a river which is not uncommonly meandering in its course. I here allude to a portion of the Severn, from its source to Shrewsbury, and I found the following numerical results:—

	Scale.	Length.	Difference.	
		Miles.	Miles.	Pr.Cent.
On the Ordnance or National Map	1 mile to 1 inch	81·8		
Index Map of the Ordnance Map	10 to 1	68·5	13·3	16·3
Petermann's River Map of the British Isles	25 to 1	62·5	19·3	23·6
Useful Knowledge Society Map of the British Isles	42 to 1	58·0	23·8	29·1

The first, the Ordnance Map, forms the basis of the other three. By comparing the Index Map with the Ordnance Map itself, the scale of which is ten times larger, the figures show that the windings of the river in the Index Map disappear to such a degree as to give a decrease of 13·3 miles for a length of 81·8 miles, or 16·3 per cent.; and so a map on a scale 25 times smaller gives a decrease of 23·6 per cent., and a map on a scale 42 times smaller 29·1 per cent.—that is, measuring off the length of a river in a map of a scale of 42 miles to 1 inch, the results, however carefully measured, are nearly one-third too small.

Thus with regard to the Jordan, although not a meandering river, and forming almost a straight line from the Lake of Tiberias to the Dead Sea, yet the few bends and windings of the river, when taken into account, give it a length of 80 English miles,* which is 11 miles longer than Professor Robinson's statement of 60 geographical miles. The 14·3 feet of fall per mile which he thus calculates, will be reduced by the 80 English miles, to 12·3 feet. And I have no doubt that when the course of the Jordan is thoroughly explored, it will exhibit a still greater development, and the rate of fall will be still more reduced.†

The fall of a river influences in part the velocity or force of its current, but not to such an extent as that the rate of fall can be taken as a scale for the rate of the velocity and force of the current. We call the Danube, the Rhine, and the Elbe very rapid rivers, and they only exhibit a fall of 1 and 2 feet, and very seldom 3 feet per mile; but we should not place the Tweed in the same rank of velocity, and yet it has an average fall of nearly 8 feet in its main course from the point of affluence of Biggar Water to the sea, which is a length of 80 miles, and with this fall is freely navigated by small boats, at least so far up as Peebles;‡ while a descent of only 2 feet in the Danube presents the greatest obstacles to navigation. Thus the mighty Amazons falls but 12 feet in the last 700 miles of its course, or one-fifth of an inch per mile; yet, from the immense volume of its waters, the collision of its current with the tide of the Atlantic is of the most tremendous description.

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* According to Robinson's Map in his Biblical Researches.

† The Jordan, as appears from Lieut. Molyneux's account, is extremely winding in its course; the American expedition under Capt. Lynch found that it serpentines 200 miles, and the fact confirms Mr. Petermann's argument.—Ed.

‡ Fullarton's Parliamentary Gazetteer of Scotland, ii. p. 775.

It is obvious from the preceding remarks, that in comparing the rate of fall of one river with another, the size, that is the depth and width, of the rivers should be taken into account.

The Jordan in point of magnitude ranks with several rivers of Great Britain. Legh compares the Jordan to the Thames below Oxford; and it appears, in collecting all the different statements for the size of the Jordan between the two lakes, that the average breadth may be considered to be about 30 yards and the depth 8 or 9 feet.* The Dee of Aberdeenshire ranks in size with the Jordan, although it is only the 29th of the British rivers in regard to the extent of its basin, and stands also far below the Jordan in this point of comparison; but this difference is balanced by the nature of the climate in which the two basins are situated. The basin of the Dee lies in a very humid region, as it drains a part of those mountainous districts of Scotland which give birth to so many perennial streams, whilst the basin of the Jordan lies in a region so arid that its tributaries are almost dried up during the summer season; and amongst those, which it does receive from the eastern water-slopes of Palestine Proper, there is not one perennial stream.

I conclude, from various measurements of the breadth and depth of the Dee, that it conveys as great a quantity of water (if not greater), to the German Ocean, as the Jordan to the Dead Sea. The mean annual breadth of the river Dee at Glenmuick parish is 70 yards, and the mean depth 4 feet; the portion of the river within this parish is 38 to 53 miles distant from its mouth; in other parts farther down the breadth is 80 yards and the depth 12 feet: thus the average breadth in its lower course, for a distance of about 50 miles, may be taken at 70 yards, and the depth from 4 to 12 feet;† and as the average size of the Jordan between the two lakes is only computed at 30 yards broad and 8 to 9 feet deep, the river Dee may fairly be ranked with the Jordan in point of magnitude.

The entire length of the Dee is 87·5 English miles, and its fall 4060 feet.‡ The greatest portion of this fall naturally belongs to the upper course, the limit of which and the middle course may be best fixed at a distance of 15·3 miles from the source; that is, at the Linn of Dee—a spot where the river has cut through opposing rocks a long narrow passage between 30 and 40 feet deep, and forms four small waterfalls, the central one about 10 or 12 feet, the others not above half that height. Below the fall the water has scooped out a series of basins, in which it rests, deep, dark, and motionless.

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* Kitto's Pictorial History of Palestine. vol. ii. p. clxxiv.

† New Statistical Account of Scotland, xii. pp. 776, 832, 875.

‡ Ibid. p. 648. The Dee takes its rise high up on Mount Braeriach, the top of which is 4220 feet high; the well or fountain whence the river springs is 4060 feet, according to Dr. Skene Keith.

From the Linn of Dee to the sea, a distance of 72·2 miles, it has yet to descend 1190 feet, which makes an average fall of 16·5 feet per mile. This is about one-fourth more than the average descent of the Jordan; and yet in the whole course of the Dee below the Linn it does not present a single waterfall or decided rapid. In some places the Dee exhibits even a fall of more than 20 feet per mile, owing to the unequal distribution of fall, to which all rivers are more or less subject, but still there are *no waterfalls* or other sudden descents.

There is another river in Scotland, the fall of which, although larger, approaches nearly to that of the Jordan. This is the famous border stream, the placid Tweed. The entire length of this river is 96·4 English miles, and the total descent is 1500 feet; thus the average fall per mile would be about 16 feet: but the actual distribution of fall for the different portions of the river is thus:—

	County.	Length.	Height.	Fall per Mile.
		Engl. M.	Engl. Ft.	Feet.
From the source	Peebles .	..	1,500	..
To affluence of Biggar Water . .	,,	16·5	605	54·2
Altarstone	,,	1·6	582	14·2
Neidpath Castle (1 mile before Peebles).	,,	8·0	518	8·0
Cardrona Mains	,,	6·4	472	7·2
Boundary between the Counties of Peebles and Selkirk . .	,,	6·3	400	11·4
Affluence of Cadon Water . .	Selkirk. .	5·0	362	7·6
Fairnielee Bridge	,,	1·3	348	10·8
Affluence of Gala Water . . .	Roxburgh .	4·4	301	10·7
Affluence of Leader Water . .	Berwick .	4·5	260	9·1
Kelso Bridge	Roxburgh .	15·4	110	9·7
The Sea	Berwick .	27·0	0	4·1
Total length and fall =		96·4	1,500	..

The affluence of Biggar Water is a very good limit between the upper and middle course of the Tweed; the distance from that point to the sea is 80 miles, which is nearly the same as the Jordan between the two lakes. We see from the preceding table that the fall of the Tweed within its middle and lower course approaches in many places very nearly to the supposed average fall of 12 feet in the Jordan, as near as 11·4 feet; and in a short distance from Biggar Water to Altarstone the rate of fall reaches even 14·2 feet per mile; and yet from the affluence of Biggar Water to the sea the Tweed possesses neither waterfalls nor rapids; and small boats, such as are used in salmon-fishing, are freely navigated.

Thus the fall of the Jordan of 12 feet per mile, even without waterfalls, does not present such a great contrast to the falls of rivers in general, as is shown by the adduced instances.

Lieutenant Symonds' measurements may therefore prove perfectly correct; and it is not at all necessary that any falls should be discovered to account for the descent of the Jordan.

But certainly there must be something to account for the striking anomaly of Professor Robinson's results and my own. The rivers which he draws up for comparison with the Jordan exhibit more or less falls, and the two rivers which I adduce here exhibit none. One might naturally suppose that this was the consequence of incorrect data on either side, upon which our results are based; but it is not so—it is the anomaly which this feature of hydrographical development exhibits; and it is only from the deficiency of study in this branch of physical geography, or rather the scarcity of data for such a study, that this anomaly has not been fully explained.

As the velocity of rivers does not altogether depend upon the rate of their descent, in like manner the average fall does not determine the formation of cataracts. It is much more the geological character of the country through which the river runs which causes those sudden descents, and countries where sudden declivities abound are chiefly of primary or transition formation. We find striking examples in every direction.

The Severn and the Shannon, for example, are much alike in magnitude. The latter descends, from Lough Allen to its mouth, a distance of 213·8 English miles, 161 feet; the Severn, from Newtown to its mouth, a distance of 210 miles, descends 465 feet. This gives an average descent per mile of 9 inches for the Shannon, and 26·6 inches for the Severn. And yet the Severn pursues its course to the sea without any rapids or falls; whilst the Shannon, with its average fall of one-third less than the Severn, forms those magnificent Rapids of Doonas, which, for grandeur and effect, rank with the most celebrated European waterfalls.

The Tweed and the Clyde exhibit a still more remarkable anomaly. Both are very much alike in point of magnitude: the extent of their basins is 1870 English square miles for the Tweed, and 1580 for the Clyde; and they are still more alike in point of their aggregate length and fall: the length of the Tweed being 96·4 miles, and its total fall 1500 feet; the length of the Clyde 98 miles, with 1400 feet of fall. Indeed both rivers for many miles from their source flow nearly in one direction, never diverging to any great distance from each other; and so long as they continue nearly parallel, they flow almost upon the same level, and keep on a high table-land of country, as if hesitating whether to mingle their waters or to remain separate, and whether to turn their courses to the eastern or western slope. Thus they pursue their sympathetic career till near Biggar, when they terminate their upper course, and like two wanderers descending from the mountains together, and separating by cross-roads when they have reached the low country, they at last part, the one turning eastward and the other westward. At this spot the rivers are only 6½ miles distant from each other—are on the same level, and have the same distance to travel ere they reach the sea—yet what a difference in their descent; the Tweed pursues its course evenly and gently; while the Clyde has not parted from its former companion for a greater distance than 18 miles, before it boldly dashes over a whole series of those well-known falls, the principal of which are the Bonnington and Stonebyres Fall, and Corra Linn. The descent over all these falls is computed at 230 feet.*

Thus the preceding examples sufficiently attest that the occurrence of cataracts and other descents in a river depends but little on its aggregate fall.

Thus there is certainly "room in the Jordan for *three cataracts*, each equal in height to Niagara," as Professor Robinson remarks; but, on the other hand, if there should not be discovered one single rapid in it, there is still nothing of a remarkable phenomenon about it.

The different points on the subject thus adduced are recapitulated as follows:—

1st. Lieut. Symonds' results for the depression of the Dead Sea, compared with the different barometrical results, do not prove such an amount of discrepancy as to justify a doubt in their accuracy.

2nd. The same results for the Lake of Tiberias are so much at variance with the barometrical results, that it seems probable the latter would prove nearer to the true level.

3rd. The fall of the Jordan of 984 feet between the two lakes, as computed from the trigonometrical results, does not exhibit an "immense contrast with all similar phenomena." And, moreover, owing to our present defective knowledge of the entire course of the Jordan, and the anomaly of the fall of rivers in general, inferences drawn from the aggregate fall of the Jordan can scarcely prove of sufficient weight to control the results of trigonometrical operations.

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* Fullarton's Parliamentary Gazetteer of Scotland, i. p. 232.

I now beg leave to add a few data on the fall of some rivers in this country, selecting such as might give a view of the great variety of descents.

The British Isles afford a wide field for the study of hydrography, and I have no hesitation in saying that it possesses for that study such extensive and valuable materials and data as no other country can boast of; but, comparatively speaking, these materials have been drawn forward, sifted, and made applicable for the promotion of science to a very limited extent. For example, the country has been levelled in all directions, and especially along all rivers of note, for the purpose of laying out canals and railways, and yet we find little information in any work regarding general results of the comparative fall of rivers.

The levels in the following data are based upon authentic documents, and relate entirely to the surface of the river above the sea at low-water. The distances have been for the first time attempted to be ascertained with accuracy.

I. *The Shannon.*—This is the third largest river in the United Kingdom, in regard to its basin.* As the fall of rivers in general is greatest at their sources, and decreases proportionately towards their mouths, the Shannon in its descent presents one of the rare exceptions to the general fall of rivers, as it is greater in its lower than in its upper course. Its source, the Shannon Pot, or more generally called Legnashinna, rises in the county of Cavan, between Upper Lough Macnean and Lough Allen, and is 345 feet above the sea. After a course of 11·6 miles, it enters Lough Allen, up to which it is rendered navigable, owing to the little descent from that place. The distance to which it is navigable is 213·8 miles from its mouth; and in this respect it is superior to all other British rivers—the navigation of the Severn extending only 192, and that of the Thames 193 miles from their mouths. From the head of Lough Allen to the foot of Lough Derg, a distance of 131·8 miles, it descends only 50·5 feet, or 4½ inches per mile. After leaving Lough Derg, the inclination of its course changes considerably, and gradually increases, till it reaches a fall of nearly 17 feet per mile between the town of Castle Connel and Castle Troy, a distance of 3·3 miles. It is in this portion where the mighty Shannon, 40 feet deep and 300 yards wide, forms the magnificent Rapids of Doonas.

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* The two larger rivers are the Humber (including the Trent and the Ouse) and the Severn.

The Fall of the Shannon.

	County.	Length.	Height.	Fall per Mile.
		Engl. M.	Engl. Ft.	Feet.
From source, Legnashinna	Cavan	..	345	..
To Lough Allen, entrance	Leitrim	11·6	161	15·9
Lough Allen, issue	,,	7·0	161	..
Carrick-on-Shannon, Bridge	,,	11·5	155	0·5
Lough Boderg and Lough Bofin, entrance	,,	12·0	131	2·0
Lough Boderg and Lough Bofin, issue	,,	4·7	131	..
Lough Forbes, entrance	Longford	4·6	128	0·7
Lough Forbes, issue	,,	2·2	128	..
Lough Ree, entrance (at the Bridge of Lanesborough)	,,	10·0	125·5	0·2
Lough Ree, issue (1·8 miles above the Bridge of Athlone)	Roscommon	17·5	125·5	..
Shannonbridge	,,	16·7	116	0·6
Lough Derg, entrance (1 mile S. from Portumna Bridge)	Tipperary	22·6	110·5	0·2
Lough Derg, issue (1·1 mile N. from Bridge of Killaloe)	,,	23·0	110·5	..
Castle Connel	Limerick	9·8	89·8	2·1
Castle Troy	,,	2·3	34·5	16·8
Limerick, Southern Bridge	,,	6·4	13·5	3·3
The Sea, between Loop and Kerry Head	Clare	62·5	0	0·2
Total length =		224·4	..	..

The Fall of the Thames.

	County.	Length.	Height.	Fall per Mile.
		Engl. M.	Engl. Ft.	Feet.
From the source, Thames Head (1¼ miles N. of Kemble)	Wilts	..	376·3	..
To affluence of Coln (0·8 miles S.W. of Lechlade Bridge)	Gloucester	22·0	243·1	6·1
Tadpole Bridge, near Bampton	Oxford	10·5	219·3	2·3
Skinner's Wear (¾ mile S. from Ensham Bridge)	,,	11·8	203·5	1·3
Oxford, Bridge to Botley	,,	7·8	190·0	1·7
Abingdon, Bridge	Berks	9·2	168·8	2·3
Clifton Ferry	,,	6·5	158·0	1·7
Affluence of Kennet at Reading	,,	25·0	119·7	1·5
Henley, Bridge	,,	8·1	106·0	1·7
Great Marlow, Bridge	,,	8·0	94·2	1·5
Windsor, Bridge	,,	13·7	65·6	2·1
Affluence of Coln, at Egham	Surrey	7·5	52·1	1·8
Affluence of Wey, near Wey Bridge	,,	7·1	40·8	1·6
Teddington, first lock	Middlesex	13·2	21·0	1·5
London, London Bridge	,,	17·6	4·3	0·9
The Sea at Nore Light	Kent	47·2	0	0·1
Total length and fall =		215·2	376·3	..

II. *The Thames.*—This noble river, although the most important in Great Britain in a commercial point of view, is only the fourth in point of magnitude. The entire length of its course is 215·2 miles, which is 9 miles less than the Shannon; its descent is 376·3 feet. Unlike the Shannon, it has a more equally distributed fall throughout its course; from its head to Lechlade, a distance of 22·0 miles, its fall is 6 feet; and from thence to its mouth its average fall is only 1·2 feet per mile.[*]

III. *The Tweed.*—We have already fully treated of this river in the foregoing observations; in point of area of its basin it ranks ninth amongst British rivers.

IV. *The Clyde.*—My results respecting the fall of this and the preceding river are almost entirely based upon levellings; the sources only of the two rivers are ascertained barometrically, and the portion of the Clyde comprising the falls has likewise not been ascertained by levelling instruments; however, that does not influence the accuracy of the general results, as the exact levels of the Clyde *above* and *below* the Falls check the intervening portion.

The Fall of the Clyde.

	County.	Length. Engl. M.	Height. Engl. Ft.	Fall per Mile. Feet.
From source	Lanark. .	. .	1,400	. .
To Clydesburn, near Little Clyde House	,,	1·8	999	222·8
Bodsberryside	,,	3·0	872	42·3
Crawford	,,	3·7	807	17·6
Affluence of Duneaton Water .	,,	5·0	734	14·6
Hardington Hall	,,	3·7	686	13·0
Wolf Clyde, Bridge near Biggar.	,,	6·0	632	9·0
Eastfield	,,	8·4	605	3·2
Bonnington Fall, *above* the Fall (height of fall 30 feet) . . .	,,	10·0	? 400	20·5
Corra Linn (height 84 feet), *above* the Fall	,,	0·7	365	7·1
Stonebyres Fall (height 80 feet), *below* the Fall[†]	,,	3·0	170	10·3 [‡]
Redleewood, near Daldowie House	,,	20·2	46	7·6
Glasgow, Glasgow Bridge . .	,,	(9·0)	?	?
Sea at Dumbarton	Dumbarton	23·5	0	1·4
Total length and fall =		98·0	1,400	. .

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[*] From Teddington to London Bridge it is 16 ft. 9 in. at low, and 1 ft. 6 in. at high water.

[†] There are two other falls of smaller dimensions, viz. the Dundaf Linn, ¼ mile below Corra Linn, 4 feet high, and one which is ½ mile below Bonnington fall. The total descent of the river from the first to the last fall—a distance of 3·7 miles—amounts to 230 feet.

[‡] The Falls excluded.

The accuracy of the data both for the Clyde and Tweed, which I ascertained from two lines of levellings quite independent of each other, are checked by a phenomenon which it might not be uninteresting to record in this place.

Both rivers are very nearly at the same level near Biggar. This very spot exhibits the remarkable phenomenon of a bifurcation of the two rivers—a bifurcation which differs from other larger (and more important) examples only so far as to depend upon the state of water in the Clyde. I give the words of the attentive angler who describes it: *—" It is a singular circumstance that salmon and their fry have occasionally been taken in the upper parts of the Clyde, above its loftiest fall, which, being 80 feet in height, it is utterly impossible for fish of any kind to surmount. The fact is accounted for in this way. After passing Tinto Hill, the bed of the Clyde approaches to a level with that of the Biggar Water, which is close at hand, and discharges itself into the Tweed. On the occasion of a large flood the two streams become connected, and the Clyde actually pours a portion of its waters into one of the tributaries of the Tweed, which is accessible to and frequented by salmon."

V. *The Dee.*—We have already noticed at some length the fall of this river. The results for the Dee I have based upon levels ascertained by repeated barometrical measurements by Dr. Skene Keith and Dr. Dickie of Aberdeen, which have been kindly communicated to me by the latter. This gentleman also confirms my statements by his personal knowledge of the Dee—that it does not exhibit any cataract from its mouth up to the Linn.

The Fall of the Dee.

	County.	Length.	Height.	Fall per Mile.
		Engl. M.	Engl Ft.	Feet.
From source	Aberdeen .	..	4,060	..
To affluence of Garchary	,,	4·3	1,984	482·8
Affluence of Guisachan . . .	,,	3·0	1,640	114·7
Affluence of Geauly	,,	5·0	1,294	69·2
Linn of Dee	,,	3·0	1,190	34·7
Ballater, Bridge	,,	26·4	780	15·6
Belwade, Bridge (not in maps) .	..	..	(310)	..
Banchory Tarnen (affluence of Feugh W.)	Kincardine	26·0	172	23·4
Drumoak	Aberdeen .	7·2	90	11·4
Affluence of Coulter Burn . .	,,	3·8	60	7·9
Sea at Aberdeen	,,	8·8	0	6·8
Total length and fall =		87·5	4,060	..

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* Stoddart's Angler's Companion for Scotland.

The source of the Dee, rising between Ben MacDhui on the E. and Braeriach on the W., is 4060 feet high, and most probably it is the highest source in the United Kingdom. The highest spring on Ben Nevis is only 3602 feet, according to my barometrical measurements—that is, 766 feet below the top of the hill; another spring, on one of the highest hills of the Grampians, Ben Aulder, reaches a height of 3650 feet.

The Fall of the entire Jordan, according to Von Wildenbruch.

	Length.	Height.	Fall per Mile.
	Engl. M.	Eng. Feet.	Feet.
From Tell el Kady, source ? . . .	..	+537·1	..
To Bahr el Hûleh,* entrance . . .	9·0	+100·0	48·6
„ „ issue	4·0	..	..
Bridge of the Sons of Jacob . .	2·5	+ 89·9	4·0
Lake of Tiberias, entrance . .	8·0	− 845·5	116·9
„ „ issue . . .	14·0	..	..
The Dead Sea	80·0	− 1446·3	7·5
Total length and fall =	117·5	1983·4	..

The spring of Tell-el-Kady forms in the preceding table the source of the Jordan; it is taken as such by the natives. The ancients give the name of the source to the spring which issues from the Cave of Panias; the latter is, however, only 2 miles longer than the former, which it receives 7 miles below its origin in the cave; there are several other streams to which the original fountain of the Jordan has been assigned—indeed its birth-place has been almost as much contested as that of Homer.

There is a considerable fall of the Jordan between the Lake Hûleh, or more correctly the Bridge of Jacob, and the Lake of Tiberias; viz., a fall of 116·9 feet per mile. This rate of fall, without cataracts, would certainly exhibit a "remarkable phenomenon;" but Von Wildenbruch expressly mentions that "from Jacob's Bridge the Jordan forms a *continuous* waterfall."

The above data are part of the results of laborious researches into the physical and statistical geography of the British Isles, which I hope ere long to lay before the public in a series of maps. However dry such tables may appear, they nevertheless form the only sound basis for the knowledge of physical geography; and it was only the want, or deficiency, of such hydrographical facts that made us until now consider the fall of the Jordan as an unusual phenomenon.

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* I computed Bahr el Hûleh to be about 10 feet higher than Jacob's Bridge; Von Wildenbruch did not measure its level, but he says that the Jordan between the two points is almost stagnant: thus a fall of 10 feet for 2·5 miles will be fully enough. The difference between Bahr el Hûleh and the Lake of Tiberias, thus implied, agree satisfactorily with other barometrical measurements.

[NOTE.—The heights for the Shannon are taken from the Ordnance Maps, except those of Castle Connel and Castle Troy, which are calculated from data given in Fraser's Handbook; those for the Thames are derived from Bradshaw's Maps of Canals of the Southern and Midland Counties, and those for the Clyde are chiefly taken from Railway Plans. For the Tweed, the height of source is determined by barometrical observation (Fullarton), and the other altitudes from Railway Plans. In the accompanying diagram I have added a section to show the whole extent of the depression of the Jordan valley. It will be observed that the southern slope is much steeper than the northern, which reaches the level of the Mediterranean at a point about 1 mile below Jacob's Bridge (101 Eng. miles from the Dead Sea), while in the Wady el Arabah the same level is attained at a distance of only about 44 miles from the Dead Sea.* Thus I compute the whole length of the depression at 190 Eng. miles—northern slope 101, Dead Sea 45, southern slope 44.]

X.—*Expedition to the Jordan and the Dead Sea.* By Lieut. MOLYNEUX, of H.M.S. Spartan.

[Read March 27, 1848.]

AFTER a very tedious passage from Beirout, Her Majesty's ship Spartan anchored off the town of Caiffa, at the southern side of the bay of Acre, and we immediately commenced putting into execution our project of carrying the ship's dingy, or smallest boat, overland to Tiberias; from thence to take her down the river Jordan to the Dead Sea; and, after a few days spent in exploring those interesting regions, to convey her back to the ship by way of Jerusalem and Jaffa. Our objects were to examine the course of the Jordan, as well as of the valley through which it runs, and specially to measure the depth of the Dead Sea. Captain Symonds, being anxious that the above views should if possible be carried out, did everything in his power to promote and further them; and as I was equally anxious to endeavour to fulfil his wishes, I was only too glad to volunteer my services for the purpose. Having therefore secured three good volunteer seamen from the ship (Grant, Lyscomb, and Winter), and having received every assistance from my messmates, by 3 P.M. on the 20th of August, 1847, all was prepared and ready for a start. We had brought Toby from Beirout to act as a dragoman, along with his two horses, tent, and canteen, which, with provisions, arms, and other requisites, were hoisted into one of the boom-boats; and at 4 P.M. we shoved off from the ship with the dingy in tow. We made sail for Acre, at the opposite side of the bay, and 2½ hours brought us under its walls, most of which have been built anew since the bombardment in 1840. We landed all the things and pitched our tent in the sand within a few yards

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* Petermann's Map of Lower Egypt, Sinai, and Arabia Petræa, in Dr. Beard's 'People's Dictionary of the Bible.'